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**Patentanmeldung Nr. Patent application No. Demande de brevet n°**

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:  
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.  
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Method of protecting from interference a frequency of a stream of data and  
circuit performing such method

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AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

Method of protecting from interference a frequency of a stream of data and circuit performing such method

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(38)

The invention relates to mixed digital analog ICs, to any electronic system processing both digital and analog information and to channel coding/modulation schemes for communication. It relates especially to the protecting of a certain frequency band of interest from interference. Many systems exist which create an interference spectrum containing discrete frequencies. Several systems exist which improve upon this by changing the discrete frequencies into a continuous spectrum with a lower over-all amplitude. For instance, this is done by deliberately introducing jitter or frequency modulation.

When the device using the system of generating a continuous spectrum as described is trying to receive a signal at a certain frequency at the same time when creating the interference, the frequency that needs protection will be disturbed.

This interference can be the cross-talk from relatively large digital signal levels to sensitive analog parts in mixed analog digital designs. To some extent this is avoided by choosing digital clock frequencies that are the least harmful for the analog part. Unfortunately, however, the digital data will not only contain multiples of the clock frequency. For more or less random data it contains an additional continuous frequency spectrum, see R. C. Frye, "Integration and electrical isolation in CMOS mixed-signal wireless chips", Proceedings of the IEEE, Vol. 89, No. 7, pp444-455, April 2001.

Therefore, an object of the invention is to provide a method of correcting a digital data signal in order to avoid the generation of interference in a certain frequency band. The stream of data transports information that is present in the form of bits and is typically a square wave signal. Another object is to provide a circuit adapted to perform the inventive method.

Regarding the method, the object is solved by a method of correcting a digital data signal in order to avoid the generation of interference in a certain frequency band, created by a stream of data that is being generated, with the method comprising the steps of

- monitoring the generated stream of data bits
- analyzing the spectrum
- correcting the spectrum without changing the digital content.

Analizing the spectrum may be performed according to the Fourier-Transformation. By correcting the spectrum in an adequate manner it is possible to create a hole in the continuos spectrum. The hole is created around a protected frequency, for example the frequency of a radio channel to be received. This situation will typically arise in a mixed analog digital design, for instance when the analogue part is trying to receive a radio channel.

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Regarding the circuit the object is solved by a circuit adapted to perform a method of correcting a digital data signal in order to avoid the generation of interference in a certain frequency band of a stream of data in a mixed analog digital design, with the stream of data transporting information that is present in the bits, comprising

- a detector whose output is a measure for the accumulated disturbance in the protected frequency band
- an edge modulator whose input consists of the digital data, with added to it the output of the detector.

According to one embodiment of the inventive method the monitoring of the generated stream of data bits is performed by a detector adapted for

- sampling the spectrum in the protected band
- generating an I and Q signal.

The direct conversion receiver may consist of two multipliers that sample the spectrum in the protected band and generate an I and Q signal.

Subsequently the I and Q signal is multiplied with another frequency to obtain a correction signal. This further frequency may either be a different one that is not used in the circuit to avoid further disturbance or again the protected frequency that is easy to obtain in the circuit. A shift in time of the edges of the stream of data is obtained by adding the correction signal to the input of a comparator.

In one embodiment correcting the spectrum is performed by introducing a shift in time of each new switching edge. These time shifts are slight and too small to cause problems in the digital domain. The shifts in time of the edges of the stream of data are obtained by adding the correction signal to the input of a comparator.

The input stream of data is typically a square wave signal with the two levels "high" and "low" with "high" corresponding to "a bit" and "low" corresponding to "not a bit". The invention derives from the perception that the spectrum of a digital signal is according to the Fourier-Transformation a continuous function with an abundance amount of frequencies. The invention is based on the comprehension that deleting one frequency or a

small frequency band from the square wave signal results in a shift in time of the edges but does not influence whether a square wave appears or not. This means the shifts do not influence the content of the data stream if they are prudently chosen.

Subsequently the output of the comparator is added to the input of the  
5 conversion receiver where it is mixed with the input, i.e. the stream of data. Leading back the output of the comparator closes the loop of monitoring the generated output stream of data bits and correcting the frequency spectrum of it.

The inventive method can work as long as the repetition of the switching  
moments, i.e. the bit rate, is much faster than the width of the frequency band that is to be  
10 protected. The reason for that is that thus the system can correct the spectrum on a time-scale that is shorter than the group-delay in the receiver of the protected band or frequency. The receiver will then always see the accumulated signal of many switching edges and the accumulated interference of many switching edges is precisely what the invention will minimize.

15 These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described herein after, wherein

Figure 1 shows a block diagram with the basic elements of the inventive  
circuit

Figure 2 shows one implementation of a circuit adapted to perform the  
20 method;

Figure 3 shows one example of a resulting spectrum for random bits as input.

Figure 1 shows a block diagram with the basic elements of the inventive  
circuit for a mixed analog digital design. The input signal is an analogue stream of data, for  
25 example radio channel with a center frequency, the output is a digital signal that has a continuous spectrum with a hole around the protected frequency. The basic elements are a detector 1 of the disturbance in the protected band which detects the spectral content and an edge modulator 2 comprising a digital data source. The edge correcting signal is generated by the detector 1 depending on the spectral content of its input signal. The detector's 1 output is  
30 the edge correction input signal for the edge modulator 2. The generated output data of the edge modulator 2 is also led back to the input of detector 1.

Figure 2 shows one implementation of a circuit adapted to perform the  
inventive method. Figure 2 shows a circuit that consists substantially of two parts: one part concerning the edge modulator 2 comprising essentially two comparators 3, 4 that perform

the edge modulation and another part containing a direct-conversion receiver that functions as the detector 1, for monitoring of the protected frequency band. The protected frequency band is for example the frequency band of a communication channel that is being received.

The protected frequency enters the detector 1 as a quadrature signal with sine and cosine

5 components. The data signal to be monitored enters via a capacitor C6. The detector 1 comprising among other components two multipliers M1, M2 and the resistors and capacitors

R5, C2, R8 and C5 monitors the spectral content of the data signal in the protected frequency

band. The I and Q components of the spectral content are integrated by the components R5,

C2, R8 and C5. Afterwards they are multiplied again by the protected frequency by a second

10 set of two multipliers M3, M4, in order to create the correction signal for the edges. This

correction signal is fed back to the digital data channel via resistor R18 and is combined with the digital input data, V<sub>in</sub>, to create the input, V<sub>comp</sub>, for a comparator.

The comparator of the edge modulator 2 of the described embodiment consists substantially of two inverters 3, 4 in a series and a resistor parallel to the inverters. The

15 implementation shown in Figure 2 presents one possibility. A completely digital version is possible as well.

Figure 3 shows a resulting spectrum for random bits as input. The spectrum  
20 contains

- peaks at harmonics of the clock frequency
- a noise-like background associated to random data and
- a hole around the protected frequency.

It becomes obvious that the spectrum contains more frequencies than the  
25 multiples of the clock frequency. As the square wave signal comprises abundant frequencies the background is noise-like. In this example the clock frequency is 300 MHz and the protected frequency is 1.0 GHz. The hole around it in the frequency spectrum indicates the strong reduction of interference at the protected frequency.

The invention may be summarized by a method for mixed analog digital  
30 designs that protects the frequencies that are of importance for the analog part. The generated stream of digital data has relative large signal levels compared to the sensitive analog parts. The stream of data bits is monitored and their frequency spectrum is corrected. The monitoring can be performed by a conversion receiver that is adapted for sampling the spectrum in a protected band and for generating an I and Q signal. A correction signal is

obtained by multiplying the I and Q signal with the protected frequency. The correction of the spectrum can be performed by using the correction signal to generate a small shift in the edges of the stream of data bits.

- 5 A circuit for performing a method to correct a digital data stream in order to protect a certain frequency, comprising a loop that is built by an edge modulator, for example a conversion receiver, whose output is combined with the input data stream of the circuit at the input of a comparator whose output data stream is again fed back to the input of the conversion receiver.

## CLAIMS:

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1. Method of correcting a digital data signal in order to avoid the generation of interference in a certain frequency band, characterized by the steps of
  - monitoring the generated stream of data bits
  - analyzing the spectrum
- 5 - correcting the spectrum without changing the digital content.
2. Method as claimed in claim 1, characterized in that the monitoring of the generated stream of data bits is performed by a detector(1) adapted for
  - sampling the spectrum in the protected band
- 10 - generating an I and Q signal.
3. Method as claimed in claim 2, characterized in that a correction signal is obtained by multiplying the I and Q signal again with another frequency.
- 15 4. Method as claimed in claim 3, characterized in that the correction signal is obtained by multiplying the I and Q signal with the protected frequency.
5. Method as claimed in claim 3 or 4, characterized in that a shift in time of the edges of the stream of data is obtained by adding the correction signal to the input of a
- 20 comparator.
6. Method as claimed in claim 5, characterized in that the output of the comparator is added to the input of the detector.
- 25 7. Circuit adapted to perform a method of correcting a digital data signal in order to avoid the generation of interference in a certain frequency band of a stream of data, with the stream of data transporting information that is present in the bits, characterized by a loop comprising:
  - a detector whose output is added to the input of



- an edge modulator whose output is at least added to the input of the detector.
-

## ABSTRACT:

A Method for mixed analog digital designs that protects the frequencies that are of importance for the analog part. The generated stream of digital data has relative large signal levels compared to the sensitive analog parts. The stream of data bits is monitored and their frequency spectrum is corrected. The monitoring is performed by a conversion receiver  
5 that is adapted for sampling the spectrum in a protected band and for generating an I and Q signal. A correction signal is obtained by multiplying the I and Q signal with the protected frequency. The correction of the spectrum is performed by using the correction signal to generate small shifts in the edges of the stream of data bits.

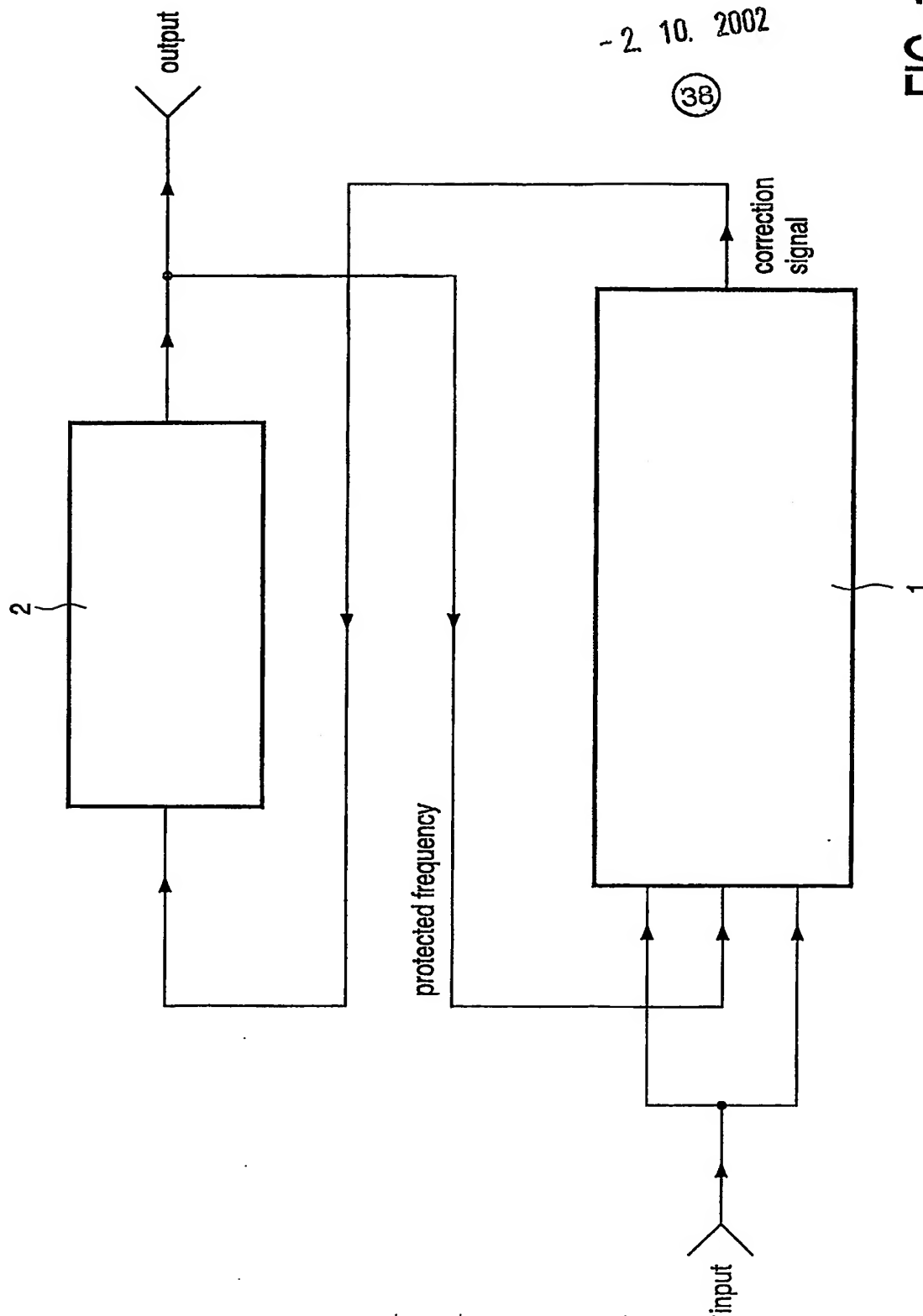
10 Figure 1

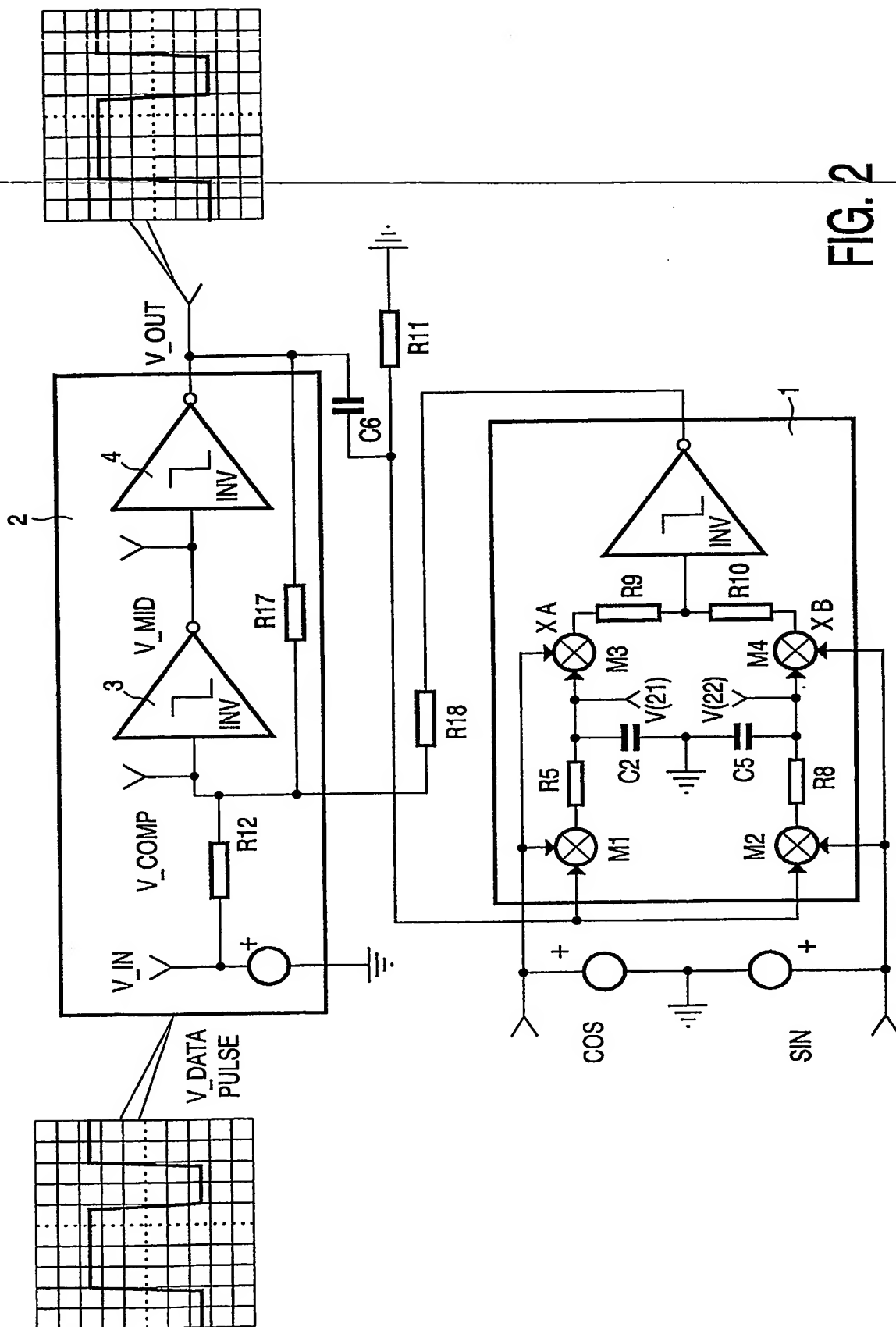
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FIG. 1





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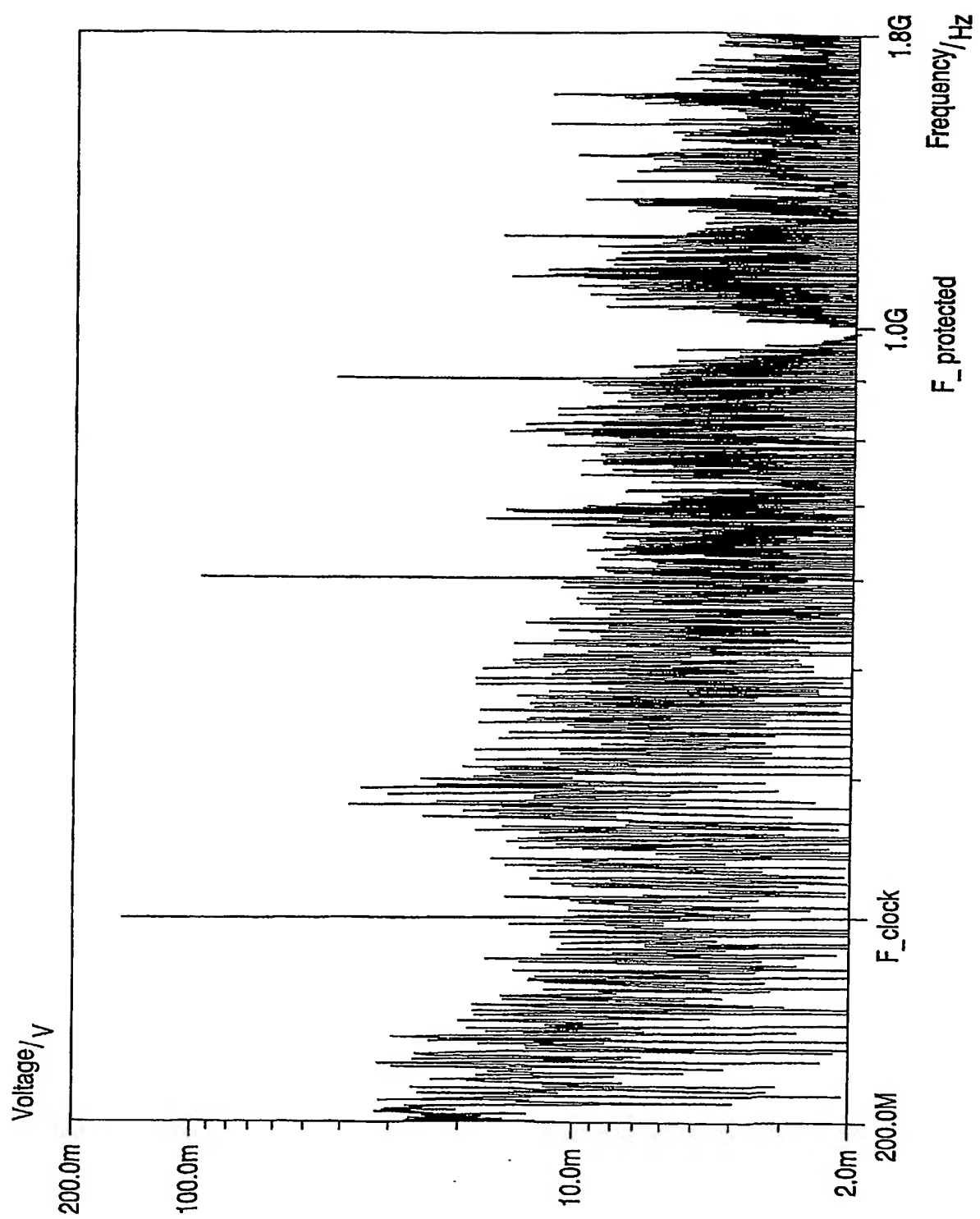


FIG. 3

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